SPECIFICATION

TITLE OF THE INVENTION

METHOD FOR TRANSMITTING CONCATENATED DATA SIGNALS

BACKGROUND OF THE INVENTION

In synchronous data systems such as the synchronous digital hierarchy SDH and a corresponding system SONET, used in North America, binary data are inserted into pulse frames and transmitted. So that signals having relatively high data rates also can be transmitted via systems which only have a restricted transmission capacity, these signals are divided into a number of subsignals having a lower data rate. A corresponding arrangement is described as "inverse multiplexers" and is known, for example, from European patent application EP 0 429 888.

In the near future, it can be expected that there will be devices, for example routers, which will deliver STM-256/OC-768 signals with about 40 Gbit/s. At present, wavelength-division multiplexer systems, the individual channels of which are designed for transmission rates of 10 Gbit/s, are still being used in optical transmission technology.

It is an object of the present invention to specify a method which enables STM-256/OC-768 signals to be transmitted via 10 Gbit/s channels.

SUMMARY OF THE INVENTION

An advantage of the method according to the present invention is that pulse frames which essentially correspond to a standardized pulse frame are used for the transmission. It is only the number of frame alignment bytes which is reduced. As such, existing transmission devices only need to be modified slightly, or not at all. The pulse frame is designed in such a manner that the operation of electric regenerative repeaters is not impaired. A uniform type of regenerative repeater therefore can be provided in the network. The original signal is transmitted transparently.

Numbering of the concatenated pulse frames is also advantageous. This enables the subsignals to be detected in a simple manner at the receiving end and to be combined in an error-free manner to form the original signal.

To ensure error-free transmission even with relatively large delay differences, it is advantageous to form a superframe. This can be done by marking, for example, the first concatenated pulse frames of a superframe or by numbering all concatenated pulse frames of a superframe.

Additional features and advantages of the present invention are described in, and will be apparent from, the following Detailed Description of the Invention and the Figures.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 shows an arrangement for carrying out the method according to the present invention.

Figure 2 shows the frame structure of the concatenated pulse frames.

DETAILED DESCRIPTION OF THE INVENTION

Figure 1 shows a possible use of the method according to the present invention. A first router ROUT1 inserts an STM-256/OC-768 signal DSA into a pulse frame PR256 (Fig. 2), delivered with a bit rate of approx. 40 Gbit/s. This signal is divided byte by byte into four concatenated subsignals IMA1 to IMA4, after omission of bytes NU, A1, A2, NU according to Figure 2, in a demultiplexer DMUX (inverse demultiplexer) so that bytes I11, I21, I31, I41, I12, I22,... of the original 256/OC-768 signal DSA are evenly allocated to pulse frames PR64.1 to PR64.4.

The precise structure of the pulse frames STM-64/OC-192 is described in ITU recommendation G.707, page 42 and pages 54 and 55. The pulse frames PR64.1 to PR64.4 used here correspond to those of the STM-64/OC-192 pulse frames completely in format and largely in content as is shown in the right-hand half of Figure 2. The representation is not true to scale. Each of these pulse frames has nine rows Z1 to Z9 and 17,280 columns S1, S2,... and the time slots formed in this manner, in each case, accommodate one byte. The ITU-conformal overhead of the pulse frames PR64.1 to PR64.4, in each case, has 576 columns. A traditional overhead includes 576 columns.

In the first row of each pulse frame PR64.1 to PR64.4, frame markings A1 and A2 are transmitted, the number of A2 bytes having been reduced by 8 bytes

and the frame alignment bytes A2 having been replaced by information bytes I11, I12,.... Only 384 time slots are reserved for the overhead information OH; in the remaining time slots, data of, in each case, one subsignal or, respectively, the STM-256/OC-768 signal DSA1 are transmitted as also in the (original) payload PL.

The first payload byte 1537 of the STM-256/OC-768 signal or, respectively, the first byte of the subsignal IMA1, is inserted as byte I11 at position 377 in the first STM64/OC-192 pulse frame PR64.1; the payload byte 1538 of the STM-256/OC-768 signal located at position 1538 or, respectively, the first byte of subsignal IMA2, is inserted as byte I21 at position 377 of the second STM64/OC-192 pulse frame PR64.2 etc. until the byte of position 1541 is again inserted as byte I12 at position 378 of the first pulse frame PR64.1 etc. Other bytes of the signal IMA1 are inserted in the first row Z1 from column 379 to column 384 and again from column 387 etc. of pulse frame PR64.1. After that, further bytes of subsignal IMA1 are inserted in the second row from column 2 to column 192, from column 194 to column 394 and from column 386 as can be seen in Figure 2.

The regenerative repeaters RE1 to RE4 shown in Figure 1 only analyze the transitions between A1 and A2 for synchronization so that the reduction in the number of A2 bytes does not impair their operation. The reduction in the number of frame alignment bytes is necessary since 9 × 69.120-1536 bytes = 620 544 bytes in total must be inserted into the four pulse frames PR64.1 to PR64.4 from the pulse frame PR256 and, in addition, eight additional bytes J0, C, B1, E1, F1, D1, D2, D3 also must be inserted into the overhead in order to generate a compatible STM-64/OC-192 pulse frame. The STM-64/OC-192 signals allocated to the concatenated subsignals IMA1 to IMA4 are additionally identified by #1 to #4.

In the basic block diagram of Figure 1, the concatenated signals IMA1 to IMA4, together with other signals, are combined to form a transmission signal WS1 in a first wavelength-division multiplexer WDM1 and transmitted. As a rule, the transmission link contains optical amplifiers OA1 and electric regenerative repeaters RE1 to REn. The regeneration (still) requires an initial division of the transmission signal by a first wavelength-division demultiplexer WDD1 into the corresponding 10-Gbit/s signals followed by an opto-electric conversion (not

shown here). After the signals have been regenerated, they are electro-optically converted and combined in a second wavelength-division multiplexer WDM2 to form the transmission signal WS2 which is forwarded via a further optical amplifier OA2 to a second wavelength-division demultiplexer WDD2 where it is reconverted into concatenated subsignals IME1 to IME4 which correspond to the subsignals IMA1 to IMA4 at the transmitting end.

In the multiplexer MUX, the regenerator section overhead inserted in the demultiplexer, bytes J0, C, B1, E1, F1, D1, D2, D3 of the concatenated signals, are in each case removed and the subsignals are mapped into the corresponding pulse frame PR256 and supplied to a second router ROUT2, again as STM-256/OC-768 signal DSE.

To be able to identify the pulse frames, they are suitably numbered which takes place in byte C. In addition, a superframe marking which can be a special binary combination can be transmitted in the C byte. Similarly, it is possible to extend consecutive numbering to the superframe. Pursuant to these measures, delay differences greater than one half frame period also can be detected and compensated for by buffers in the multiplexer MUX. An analogous facility is provided for transmitting signals in the reverse direction.

Although the present invention has been described with reference to specific embodiments, those of skill in the art will recognize that changes may be made thereto without departing from the spirit and scope of the invention as set forth in the hereafter appended claims.